

**REHABILITATING SEWERAGE LINE SYSTEM IN CONGESTED URBAN
AREA**

MOHD NOR SIZA BIN DAUD

**A project report submitted in fulfilment of the
Requirements for the award of the degree of
Master of Science (Construction Management)**

**Faculty of Civil Engineering
Universiti Teknologi Malaysia**

FEBRUARY 2015

DEDICATION

Glory and praises be to God the Almighty
for the completion of this project report

To my beloved mother and father
who have been my inspiration. Without their love and support
this project would not have been made possible

Thank you for all love and inspiration
throughout the entire creation of this project report.

ACKNOWLEDGEMENT

Here, I would like to thank mainly to Allah Almighty because successfully to completed a project paper. Thank you also to my supervisor, Dr. Rozana Zakaria had much help, advices and given suggestions to prepare this paper project. Also thank to all panel examiners to comment, given suggestion and opinion to overall my project. Thanks also to my family and friends for their support and encouragements for completed paper project.

ABSTRACT

Since 1957, after Malaysia independent, there were only few proper sewerage systems because of low population density in urban area and not rapid urban developments. After 57 years of independent and in Malaysia heading to be a developed country by 2020, the restoration of good condition sewerage line system, its operation and maintenance is very important at urban area. There are challenges when the rehabilitation works for sewerage line system is carried out in developed area. In rapid development area for sewerage line, the space areas are very limited and congested. Besides many other utilities are sharing road services areas. The paper highlights the investigation of common problems occur installation of sewerage line system and propose suitable area for sewerage line system that will help designer in making decision to selecting sewerage line system alignment. Questionnaires were distributed to respondents in order to gain information of data collection. The feedbacks were analysed using descriptive analysis with the help of SPSS and excel in order to priorities the main problem in rehabilitation sewerage line system in congested urban area. This study found improvement in systematic sewerage rehabilitation planning in congested urban area, determination of effective rehabilitation methods and substitution pipe materials, improvement of construction methods and providing clean and fresh environment of surrounding area are the key factors in the justification of rehabilitation works of sewerage line system in urban area.

ABSTRAK

Sejak tahun 1957, selepas Malaysia merdeka, terdapat hanya beberapa sistem pembetulan yang sesuai kerana kepadatan penduduk yang rendah dan bandar tidak membangun dengan pesat. Selepas tahun 57 merdeka Malaysia menuju ke arah negara maju menjelang tahun 2020, pemulihan keadaan sistem talian pembetulan, operasi dan penyelenggaraan adalah sangat penting di kawasan bandar. Pelbagai cabaran-cabaran apabila pemulihan kerja-kerja untuk sistem talian pembetulan dijalankan di kawasan maju. Kawasan pembangunan yang pesat menyebabkan sistem pembetulan mempunyai ruang yang sangat terhad dan padat. Selain itu banyak utiliti lain dalam kawasan jalan raya. Tujuan kajian ini adalah untuk mengenal pasti masalah utama dihadapi dalam memulihkan sistem talian pembetulan dan cadangan kawasan yang sesuai untuk sistem pembetulan bagi membantu pereka bentuk dalam menentukan pemilihan jajaran sistem pembetulan. Borang soal selidik akan diedarkan kepada orang untuk mendapatkan maklumat pengumpulan data. Maklum balas yang akan dianalisis mengenai masalah utama dalam pemulihan sistem talian pembetulan di kawasan yang sesak dengan menggunakan analisis deskriptif dengan bantuan SPSS dan excel. Kajian ini dijangka dapat meningkatkan sistematik perancangan pemulihan pembetulan di kawasan bandar yang sesak, menentukan kaedah pemulihan yang berkesan dan bahan paip penggantian, meningkatkan kaedah pembinaan dan menyediakan persekitaran yang bersih dan segar dari kawasan sekitar adalah kunci utama untuk membuktikan dengan wajar kerja-kerja pemulihan sistem pembetulan.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENTS	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	viii
	LIST OF TABLES	xii
	LIST OF FIGURES	xiv
	LIST OF ABBREVIATIONS	xvii
	LIST OF SYMBOLS	xviii

TABLE OF CONTENTS

1.0	BACKGROUND STUDY	
1.1	Introduction	1
1.2	Research Background	3
1.3	Study Problems	4
1.4	Aim of the Study	5
1.5	Ojective of the research	5
1.6	Scope of Study	6
1.7	Brief Methodology	6
1.8	Expected Findings	7
1.9	Significant of Study	8
2.0	LITERATURE REVIEW	
2.1	Introduction	9
2.1.1	Sewer Rehabilitation Technologies	10
2.1.1.1	Stabilization Technologies	11
2.1.1.2	Lining Technologies	11
2.1.1.3	Coating Technologies	12
2.1.1.4	Excavation and Replacement Technologies	13
2.2	Type of Sewerage Line System	13
2.2.1	Gravity Sewerage System	14
2.2.2	Vacuum Sewerage System	15
2.3	Construction Method for Sewer line	17
2.3.1	Open Trench(open cut)	18
2.3.2	Pipe Tunnelling(Pipe Jacking)	19
2.4	Material for Sewer Line	21
2.4.1	Verified Clay Pipe	22
2.4.2	Reinforced Concrete Pipe	23

2.4.3	Ductile Iron Pipe	23
2.4.4	Polyethylene Pipe	24
2.4.5	Mild Steel Pipe	24
2.5	The Purpose of Sewerage lineScope Study	25
2.6	The Matter of Rehabilitating Sewerage Line	26
2.7	The Potential Impact without Analysing Problems	26
2.8	Factor of Influence for Analysinthe Rehabilitating	27
2.8.1	Space Area	27
2.8.2	Congested Area	28
2.8.3	Masses of Services	29
2.9	Summary	29
3.0	METHODOLOGY	
3.1	Introduction	31
3.2	Data Collection	33
3.2.1	Primary Data	33
3.2.2	Secondary Data	34
3.3	Data Analysis	35
3.4	Result and Finding	36
4.0	DATA ANALYSIS AND RESULTS	
4.1	Introduction	37
4.2	Analysis of Demographic Information	38
4.2.1	Analssis of Respondents Background by Sector	38
4.3.2	Analssis of Respondents Working Experienced	39
4.3.3	Analssis of Respondents Qualification	40
4.3.4	Analysis of Respondents Measure Project Government Completed	41
4.3.5	Analysis of Respondents Measure Project Semi- Government Completed	43
4.3.6	Analysis of Respondent Measure Private Sector Project Completed	44
4.4	Correspondences Demographic Section B	45

4.4.1	Common Problem Occur Rehabilitating sewerage Line system	45
4.4.2	Common Problem Occur Rehabilitating Sewerage Line in Congested Urban Area	45
4.4.3	Common Problems Rehabilitating Sewerage Line System For Buildability Factor	46
4.4.4	Common Problems Rehabilitating Sewerage Line System For Design Factor	48
4.4.5	Common Problems Rehabilitating Sewerage Line SystemFor Technology Factor	49
4.4.6	Common Problems Rehabilitating Sewerage Line System Environment Factor	51
4.4.7	Common Problems Rehabilitating Sewerage line System For Economic Factor	52
4.4.8	Common Problems Rehabilitating Sewerage Line System Sosial Factor	53
4.4.9	Common Problems Rehabilitating Sewerage Line SystemFor Land Factor	55
4.4.10	Common Problems Rehabilitating Sewerage Line System For Safety and health	56
4.4.11	Common Problems Rehabilitating sewerage Line System for All Factor	57
4.5	Correspondences Demographic Section C	60
4.5.1	Pro and Cons Factor Rehabilitating Sewerage Line for Open Cut System	60
4.5.2	Pro and Cons Factor Rehabilitating Sewerage Line for Pipe Jacking System	62
4.5.3	Pro and Cons Factor Rehabilitating Sewerage Line for Vacuum Sytem	63
4.5.4	Pro and Cons Factor Rehabilitating Sewerage Line forStabilization Technologies System	65
4.5.5	Pro and Cons Factor Rehabilitating Sewerage Line forLining Technologies System	66

4.5.6	Pro and Cons Factor Rehabilitating Sewerage Line for Coating Technologies System	68
4.5.7	Pro and Cons Factor Rehabilitating Sewerage Line for Excavation and Replacement Technologies System	69
4.5.8	Pro and Cons Factor for Selecting Area and All Typen Of Rehabilitating Sewerage Line	71
4.6	Correspondence Demographic Section D	73
4.6.1	Criteria in Selecting Suitable Area for Economic	73
4.6.2	Criteria in Selecting Suitable Area for Sosial	74
4.6.3	Criteria in Selecting Suitable Area for Environment	75
4.6.4	Criteria in Selecting Area for All Categories	76
4.7	Respond from Personnel Interview	77
5.0	CONCLUSION AND RECOMMENDATION	
5.1	Introduction	81
5.2	Objective 1: Common Problem Occur Rehabilitating Sewerage Line in Congested Urban Area	82
5.3	Objective 2: Pro and Cons Criteria For Selecting Suitable Area and Type of Rehabilitating Sewerage Line	84
5.4	Objective 3: Criteria in Slecting Area for Sewrage Line Alignment	85
5.5	Overall Conclusion	87
5.6	Limitation of Study	88
5.7	Recommendation for Future Research	89

LIST OF TABLES

TABLES	TITLE	PAGE
3.1	Average index and level of importance.	35
4.1	Frequency and valid percent presenting respondents categories.	38
4.2	Frequency and valid percent representing respondents working Experienced.	39
4.3	Frequency and valid percent representing respondents working qualification holder.	40
4.4	Frequency and valid percent representing respondents government Project .	42
4.5	Frequency and valid percent representing respondents semi-Government project.	43
4.6	Frequency and valid percent representing respondents project private sector.	44
4.7	Common prolems rehabilitating sewerage line system	46
4.8	Common prolems rehabilitating sewerage line system for buildability .	47
4.9	Common problems rehabilitating sewerage line system for design Factor.	48
4.10	Common problems rehabilitating sewerage line syste for Technology Factor.	50
4.11	Common problems rehabilitating sewerage line system for Enviroment factor.	51
4.12	Common problems rehabilitating sewerage line for economic Factor.	52

4.13	Common occur problems rehabilitating sewerage line system for social factor.	54
4.14	Common occur problems rehabilitating sewerage line system for land factor.	55
4.15	Common occur problems rehabilitating sewerage line system for Safety and health factor.	56
4.16	Pro and cons factor for selecting suitable area and type for open Cut system.	61
4.17	Pro and cons factor for selecting suitable area and type for pipe jacking system.	62
4.18	Pro and cons factor for selecting suitable area and type for Vacuum system.	64
4.19	Pro and cons factor for selecting suitable area and type for Stabilization technology system.	65
4.20	Pro and cons factor for suitable area and type for lining Technology system	67
4.21	Pro and cons factor for selecting suitable area and type for coating Technology system	68
4.22	Pro dan cons factor for selecting suitable area and type for Excavation and replacement technologies technology system	70
4.23	Criteria rehabilitating sewerage line system for economic factor	73
4.24	Criteria rehabilitating sewerage line system for social factor	74
4.25	Criteria rehabilitating sewerage line system for enviroment factor	75
4.26	Method constructions at site D47	78
4.27	Common problems in rehabilitating at site D47	78
4.28	Pro and cons for selecting suitable area and type of Rehabilitating sewerage line system at D47	79
4.29	Criteria for selecting rehabilitating sewerage line alignment At site D47	80

LIST OF FIGURES

FIGURES	TITLE	PAGE
2.1	MH 2-6 – MH 2-7 – Open cut with gravity sewer system (Source From Site D47,2014)	15
2.2	Valve pit(Source internet)	17
2.3	Pipe jacking MH 6-13 – Pipe Jacking (Source From Site D47,2014)	20
2.4	VCP(Score From Stored on Site Baiduri)	22
2.5	Excavation at existing develop area (Source From Site D47,2014)	27
2.6	Excavation at existing development area effects the traffic flow (Source From Site D47,2014)	28
2.7	MH 2-1 Jalan Utara (Source From Site D47,2014)	29
3.1	Methodology Flow Chart.	32
3.2	Layout Plan D47- Submission Drawings(SS/PDC/2) (Source Ciptamas Consult, May 2013)	34
4.1	Respondents categories.	39
4.2	Respondents working experienced.	40
4.3	Respondents qualification holder.	41
4.4	Respondents government project.	42

4.5	Respondents semi-government project.	43
4.6	Respondents private project.	44
4.7	Common problems rehabilitating sewerage line system for build Ability factor (Mean score ≥ 3.5)	47
4.8	Common problem rehabilitating sewerage line system for design Factor (Mean score ≥ 3.5)	49
4.9	Common problem rehabilitating sewerage line system for Technology factor.	50
4.10	Common problem rehabilitating sewerage line system for Environment.	52
4.11	Common problem rehabilitating sewerage line system for Economic factor.	53
4.12	Common problem rehabilitating sewerage line system for Social factor.	54
4.13	Common problem rehabilitating sewerage line system for Land factor	55
4.14	Common problem rehabilitating sewerage line system for Safety and health factor.(Mean score ≥ 3.5)	56
4.15	All Common Problem Rehabilitating Sewerage Line System	59
4.16	Pro and cons factor for selecting suitable area and type for Open Cut System	61
4.17	Pro and cons factor for selecting suitable area and type for Pipe jacking	63
4.18	Pro and cons factor for selecting suitable area and type for Vacuum System(Mean score ≥ 3.5)	64
4.19	Pro and cons factor for selecting suitable area and type for Stabilization technologies(Mean score ≥ 3.5)	66

4.20	Pro and cons factor for selecting suitable area and type for Lining technology system(Mean score ≥ 3.5)	67
4.21	Pro and cons factor for selecting suitable area and type for Coating technology system(Mean score ≥ 3.5)	69
4.22	Pro and cons factor for selecting suitable area and type for Excavation and replacement technology system(Mean score ≥ 3.5)	70
4.23	All Pro and Cons for Selecting Suitable Area and Type	72
4.24	Criteria rehabilitating sewerage line system for criteria economic factor(Mean score ≥ 3.5)	74
4.25	Criteria rehabilitating sewerage line system for criteria social factor (Mean score ≥ 3.5)	75
4.26	Criteria rehabilitating sewerage line system for criteria enviroment Factor (Mean score ≥ 3.5)	76
4.27	All Criteria Rehabilitating Sewerage Line Alignment (Mean score ≥ 3.5)	77

LIST OF ABBREVIATIONS

PPTM	-	Pertubuhan Penduduk Tahunan Malaysia
IWK	-	Indah Water Consortium
SSD	-	Sewerage Servis Department
MS	-	Malasian Standard
TNB	-	Tenaga Nasional Berhad
HDPE	-	High Density Polyethylene Pipe
VCP	-	Vitrified Clay Pipe
PE	-	Polyethylene Pipe
TIE	-	Technical Instruction Engineer

LIST OF SYMBOLS

Σ	-	Summation
N	-	Total number of response
a_i	-	Constant expressing the weight to each response (1 to 5)
x_i	-	Frequency of the response
\geq	-	Greater-than or equal to
\leq	-	Less-than or equal to
R	-	Respondent

LIST OF APPENDIXS

APPENDIX	TITLE	PAGE
A	Questionnaire	92
B	Questionnaire interview	100
C	Permission for data collection	104

CHAPTER 1

BACKGROUND OF STUDY

1.1 Introduction

Towards the urbanisation of a country, the urbanities processes pressured the infrastructure needs and the requirements are increased or take place in any nation. This scenario is also impacted due to the demand of sewer line system that needs to be upgraded or rehabilitate. The Prime Minister of Malaysia set the goal to implement Green Technologies. One of the objectives of Green Technologies is to focus about the management of sewerage system including the sewerage line, Malaysia Environment Industry (2010). According to the Sustainability Report 2011 of Indah Water Konsortium, the organization has been practicing the reuse of sewage by-products at 13 of their regional plants as an initial effort to conserving water, energy and the environment. The reuse of the treated effluent from their plants is currently confined to internal housekeeping or non-potable use, such as STP compound cleaning, vehicles cleaning and watering of plants for landscaping purposes. A good planning and strategic management system on the sewerage line and the sewerage treatment plant in Malaysia should provide a clean and fresh environment, in which the sewerage line system should not contributes from any leakage and blocking of sewerage pipe lines. Poor operation and maintenance of sewerage line would contribute to bad smell and dirty surrounding.

According to Keith Hanks (2004), the city of Los Angeles has conducted an evaluation to the methods that is used to rehabilitate its major noncircular cross-section sewers. The rapid growth of Los Angeles has brought to the attention of the public in many ways during the past few years and especially by the recent census taken by the Federal government. In January, 1920 had a population of 576,673 which is an increase of 81 % over its population of 319,198 in 1910. The cause of that needs a major rehabilitation or replacement considerations. (Keith Hanks, 2004).

While in Taiwan construction case, the completion of the new infrastructures of sewerage started from 2000 until 2007, sewerage rehabilitation planning is considered as a major work (Jyh-Bin Yang and Pi-Yun Liao, 2008). The systematic sewerage rehabilitating planning consists of sewer inspection, diagnosis of pipe defects, grading of sewerage structural conditions and determination of cost-effectiveness rehabilitation methods and substitution pipe materials. Sewer line systems are important infrastructures for developing and developed countries. The percentage of the connected houses is regarded as the critical index of national competitiveness. Taking the example of Taiwan, up to October 2009; the percentage of the connected houses in Taiwan is about 22.1% and annually increases about 1.65 %. Due to the invisibility of sewer line systems, the sewer systems are usually difficult to maintain, monitor and rehabilitate (Ming-Der Yang, Tung-Chiang Su, 2001). Furthermore, the negligence in the sewerage pipe failures increases the maintenance and rehabilitation costs significantly. Additionally, even though when the financial condition turns into a limit, the economical and effectiveness of the sewerage line system rehabilitation methods become necessary. (M.D.Yang *et al.*, 2010).

On other example, the deterioration, inadequacy and insufficiency of the nation's infrastructure is a serious problem affecting the United States. Several important organizations have documented this problem extensively and provided specific recommendations for the research. The task group agreed that the civil urban infrastructure has not been properly maintained to meet the present society needs. The task group also identified the important barriers that are currently precluded by the United States civil systems. Furthermore, the task group recommended a research strategy to address the rehabilitation of civil urban infrastructure through the

application of a holistic systems approach that includes the issues of system behaviour, deterioration and renewal. (M. Reyna, *et al.*1994). Although sometimes ignored in early pipeline rehabilitation projects, manholes are inherently susceptible to the same forms of deterioration as the pipe lines carrying the waste. In the U.S today, over 20 million manholes provide the primary means of access for inspection and repair of collection systems. (Joanne B. Hughes, 2004). According to Trenchless Technology Magazine (2010), 20% of the manholes area at least 50 years old and another 25% are 30 to 50 years. Additionally, more than three million are believed to be suffering from serious structural decay and are in need of immediate rehabilitating or replacement. (V.Firat Sever, Mohamad Najafi, Abhay Jain, et al, 2013)

1.2 Research Background

The increase of the urban population caused to waste water treatment plants expanded, and sewerage lines have to be replaced, and their replacement is not only expensive but also disruptive since many sewer lines are buried under the public streets. According to the 2005 census, the population of the Petaling district is at a density of 1418.700 for 2929.3/km² (PPTM ICT, 2014). According O.S Abu-Rizaiza, (2000), in the early 1960s, Jeddah expended the it sewerage line system because the population quadrupled to around 1300, 000(Farsi 1997), due mainly to migration area is 14.6 km². Water demand rose to 45,000m³/day. New sewerage systems were thought too costly to build and run, and disposal through cesspools was believed economic and adequate. There were three major entities that is involved in the development of a private sewerage system. Firstly, Sewerage Service Department is responsible to enforce the legal requirements and the processes in protecting the consumers. The second is the Indah Water Consortium (IWK) which basically looks after the consultant and the contractor to execute the works and the third is the developer which is presented by his consultant and his contractor to execute the sewerage lines and treatment plant. The sewerage system should be complying with MS 1228, Sewerage Service Department's guideline and specification. (SSD, 2003).

The sewerage lines were a collection of waste water-services from houses, shops, factories, offices, canteen and public toilets to the sewage treatment plant. The maximum length that is allowed by the IWK was 100 m length from manhole to manhole or complying with Malaysian Standard (MS 1228: 1991). The sewerage lines were connected from one manhole to another manhole to temporary restore the sewage before transferring to the sewage treatment plant with sewer lines.

Usually installations of sewerage lines are by open excavation method and there were two types of methods to construct the sewer line by open cut excavation. It could be done vertical or slanting shapes. The advantages of vertical open cut is to retain the earth from collapse by using sheet pile. Meanwhile, the open excavation using slanting shape using a big construction area compared to vertical excavation. In some cases of open excavation were not suitable, the sewerage line installation used pipe jacking method.

1.3 Study Problems

Construction of sewerage line system in congested area or developed area is very challenging and required special consideration to accomplish the job. The most common problem about this situation was a heavy traffic nearby or the sewerage line cross the road. Diversion of traffic makes many parties affected during the construction until the project is complete. Besides that, the common problem is the congested services in road reserved. The utilities cable such as telecom, TNB, gas Malaysia, water pipe and other in the area. When this situation involved the sewer line need to be relocated to another area and incurred new alignments of sewerage line. This study is therefore aims to identify what are the common problems of rehabilitating sewerage line system and the best area that is suitable for the new sewerage line system. The construction work of upgrading the sewage line is considered complicated, especially at the congested areas with rapid transportation

infrastructures. These resulted to small and narrow areas in order to execute construction work and the work is also challenging because of many underground services. These problems can effects the time, cost and design. The installation pipe line must be accurate. The prediction and controlling of the installation works of sewerage pipes have to be very careful to ensure that the structure integrity of installation pipes is achieved.

1.4 Aim of the Study

The aim of this study is to investigate the problems occurred due to the installation of sewerage line system and propose suitable area for sewerage line system that will help the designer in making decision to selecting sewerage line system alignment.

1.5 Objective of the Research

The objectives of this study are as followings:

- i. To identify the common problems that is occur in rehabilitating sewerage line.
- ii. To determine pro and cons in selecting suitable areas and types of construction for sewerage line.
- iii. To propose criteria in selecting area for sewerage line alignment.

1.6 Scope of Study

This study was only focused on areas that are found dense populated and congested areas. A consideration is also taken to areas which sewerage lines as well as treatment plants that were sized and constructed before the rapid growth i.e. last 10 to 20 years. Therefore the current-growth now provides challenges to the ability of the systems to handle the amount of waste being generated-in current. The case study was conducted at zones D 47, Petaling Jaya Utara. The total length for rehabilitating sewerage line approximate is 35,494 m with 530 numbers of manholes and a few existing pump houses. The division of the pipeline system consist of 5,986 m length by force main method and 29,498 m length by gravity fall sewer line system.

1.7 Brief Methodology

The main methodology of this study is by distributing the questionnaires to respondents who are involved in sewerage line construction. There were a few stages that were followed. The first stage involves, the literature that is reviewed from journals, guideline, books, magazine, thesis, website and progress report also used to enhance the findings of the primary data collection thus develop the relationship between the theory and the findings form on ground data collection. The data provide wide range of information and knowledge pertaining construction the rehabilitation sewerage line in development areas. After that, the data collection were from two sources, first data collected from questionnaire survey by the relevant identities in site D 47, Petaling Jaya Utara, and also the personal interviews on site.

After the data has been collected, descriptive analysis were applied with the used of SPSS and excel. The evaluation is to get or provide and develop the finding

of this study. The finding would be helped to identify the appropriate way of construction in rehabilitation sewerage line within the congested area.

The later the findings were compared between questionnaire survey which is perspective results and real construction condition at site D 47, Petaling Jaya Utara. The last step was the compilation of conclusion and recommendation which concluded major problems faced in constructing sewerage line and the proposal was made for the suitable options in selecting sewerage line alignment in congested urban areas.

1.8 Expected Findings

The expected findings from this project are:

- i. Problems such as building abilities, design, technologies, economic, social, environment, land, safety and health in rehabilitation of sewerage line system in congested urban areas.
- ii. Factor such as easy to construct, land or space area, authority requirements, geographical areas, low cost, enhance visual impact of surrounding areas, used reserved constructs, growth rapid transport problems, used/application of high technology and expensive cost are impacted to the efficiency of construction sewerage line system and significant parameter that contribute to the development sewerage line system.
- iii. Suitable area for rehabilitating sewerage line such as growth population is the criteria ascertain.
- iv. The most proper criteria in selecting the alignment for rehabilitating sewerage line system in congested urban areas. The example guidelines are economic, social and environment.

1.9 Significant of Study

This study will give ideas to the contractor, consultant, developer and client carefully to plan the successful mission of rehabilitating sewerage line system in congested urban areas. This study outcome will also provide information and knowledge to the contractor, consultant, and developer to select appropriate method for constructing sewerage line system.

REFERENCES

- Camilo Garcia, Dulcy M. Abraham, Sanjiv Gokhale and Tom Isaley (2002), *Rehabilitating Alternatives for Concrete and Bricks Sewers*. Construction Best Practice (Revision 01), October 2008.
- David Butler and John W. Davies, *Urban Drainage*-3rd Edition, 2009.
- D. Bairaktaris, V. Delis, C. Emmanoulidis, S. Frondistou-yannas, K. Gratsias, Kallidromitis and N. Rerras (2007), *Decision-Support System for the Rehabilitation of Deteriorating Sewers*.
- Falguni K.P. Mishra, Niladri Bihari Mahanty (2012), *Characterization of Sewage and Design of Sewage treatment Plan*.
- Institut Piawaian dan Penyelidikan of Malaysia , *Malaysian Standard MS 1228 : 1991*.
- Jyh-Bin Yang and Pi-Yun Lio(2008), *Analysis of Delay Causes for Pipe Line Projects in Sewage System : Taiwan Case*.
- Joanne B. Hughes (2002), *Manhole Inspection and Rehabilitation*.
- Keith Hanks, Pipelines (2002), *City of Los Angeles Major Sewer Rehabilitation or Replacement Considerations*.
- Ma, Zuhuanyan Yang (2004), *Finite element analysis of influence of pipe jacking construction on environments*.
- Malaysian Sewerage Industry Guidelines, *Sewer networks and pum station* (Volume III).
- M.D Yang, T.C. Su, et al. (2010). *Sewerage Rehabilitation Planning*.
- Ming-Der Yang, Tung-Ching Su (2004), *An optiimization model of sewerage rehabilitation*.
- Ming-Der Yang, Tung-Chiang Su(2001), *An optimization model of sewerage rehabilitation*.

- O.S. Abu-Rizaiza (2000), *Jeddah City with and Without Sewerage: Cost Comparison.*
- Paul Noran and Patrick Obenaul (2010), *Asset Management of a Failing 36" Ductile Iron Sewage Force Main.*
- Raghvendra Bhargava (2012), *Planning, Design and Constructability Aspects of Longer Trenchless Drives for Gravity Sewer Installations.*
- Santiago M.Reyna, Jorge A. Vanegas, Associate Member, ASCE and Abdul H. Khan. (1994), *Construction Technologies for Sewer Rehabilitation.*
- Shan He and Akira Koizumi (2013), *Damage Discrimination Analysis with Quantification Theory for Sewerage Pipe System.*
- Soma Bhadra, P.E, and Denny Moss (2011), *Vacuum Sewer – A Viable Alternative for Wastewater Collection and Transport in Coastal Area.*
- Taylor (2004), *Construction specification requirements for water and sanitary sewer.*
- Tchobanoglous, G. (1981). *Wastewater Engineering: Collection and Pumping of Wastewater.* McGraw-Hill, New York.
- Upgrading urban communities* copyright@1999-2001.
<http://web.mit.edu/urbanupgrading/index.html>.
- V.Firat Sever, Mohamad Najafi, Benton & Associates, Nedderman Hall Arlington (2013), *No-Dig Manhole Rehabilitation Knowledge Gaps.*
- What are key urban environmental problems?*
<http://web.mit.edu/urbanupgrading/urbanenvironment/index.html>.
- Why are Vitrified Clay Pipes Environmentally Friendly?". Expert Rooters.
 Retrieved 30 January 2015.
http://en.m.wikipedia.org/wiki/Vitrified_clay_pipe.
- Yong Chen, Youngguang Chen and Yihua Huang (2011), *The Application of Long-Distance Curved Pipe Jacking in Power Pipe Construction.*
- Zhuangyun Yang (2011), *Insight into Some Aspects of Pipe Jacking Techniques during Long Distance Installations in Municipal Engineering.*
- Zhuanyun Yang (2012), *Pipe-soil Interaction Effect on Construction of Curve Pipe-jacking.*